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ABSTRACT

The basic movement pattern used in skilled individual rope jumping performance was determined and used as a model against which to evaluate the rope jumping form used by children at various levels of skills development. The techniques of adults and nursery school children were filmed and analyzed. The specific causes of unsuccessful attempts were identified tentatively and categorically. Performances which met an arbitrary minimal standard of success (two consecutive, continuous successful jumps) were analyzed to determine the general sequence of rope jumping movements and the changes in timing of arm-leg coordination as speed increased. From various levels of skill demonstrated by the children, it was possible to sort out changes in leg action, arm and hand movements, and arm-leg coordination that seemed to represent developmental changes in rope jumping form. Despite the variety of style in leg movements and other aspects of form in the initial stages of skill development, the developmental movement patterns in rope jumping changed progressively to a narrowly singular one used in speed jumping. (Author/JA)

ROPE JUMPING: A PRELIMINARY DEVELOPMENTAL STUDY
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Purpose of the Study. The purpose of this preliminary study was two-fold; (1) to establish a standard of mature form for individual rope jumping and (2) to get an overview of the changes that occur as children progress toward the mature pattern.

Procedure. Since the velocity factor has been applied when determining mature form in most other fundamental skills, the same procedure was followed in this study. The successful application of speed was found to produce the economy of movement and highly precise arm-leg coordination that is characteristic of skilled performance and it yielded amazingly similar rope jumping patterns. The standard of mature form arrived at in this study is a composite of the common elements in the form used by a group of children engaged in competitive speed jumping and a group of adult amateur athletes who regularly included speed jumping in their year-around training routines. Their performances were filmed and analyzed with respect to arm movements, leg and trunk movements, and arm-leg coordination. After the mature form had been established, 120 nursery and kindergarten children were filmed from front and side views with a 16 mm camera set at 64 f/sec as they attempted to jump rope. All the children had practiced rope jumping on several occasions prior to the filming sessions. Their performances were analyzed subsequently in terms of the mature form with special attention given to possible trends in movement pattern maturation. Analysis was focused on the three aspects of the movement pattern which was used in determining mature form.

Mature Individual Rope Jumping Form.

1. Rope turning movement. The rope is held in a power grip with the thumbs pointing sideward, the upper arms extend downward and obliquely sideward with the elbows near the sides of the trunk, the forearms are bent sideward at the broad angle of about 135 degrees, the rope describes a circular path as it is moved by wrist circumduction combined with forearm pronation and supination, and the hands remain below the waist and mostly in front of the forward plane of the trunk during the turn. As can be seen from Figures I and II, there is wrist-forearm circumduction with the elbow acting as the pivotal point.

2. Jumping movement. Legs are close together and remain slightly flexed at the hips and knees throughout the jump, the feet are quickly raised and then pushed back downward after the rope has been cleared, feet clear the floor one to three inches, there is little plantar flexion at push-off, the head rises imperceptibly during the jump, and the trunk is bent forward somewhat. Rope clearance is actually a leg lifting movement rather than a typical upward jumping motion.

3. Turn-jump timing. The jump begins after the rope passes forward and beyond the vertical, the rope touches the ground approximately even with the front of the feet, the height of the feet is reached as the rope passes beneath the body, and there is but one jump for each turn of the rope.

There are few variations in the style of speed jumpers such as the amount of forward trunk bend, and the use of a one or a two-footed jumping style. However, these small differences do not change the basic mature pattern as just described. The two key features of the pattern are the limited arm action providing a nearly circular rope turn and the leg lifting type of jump.

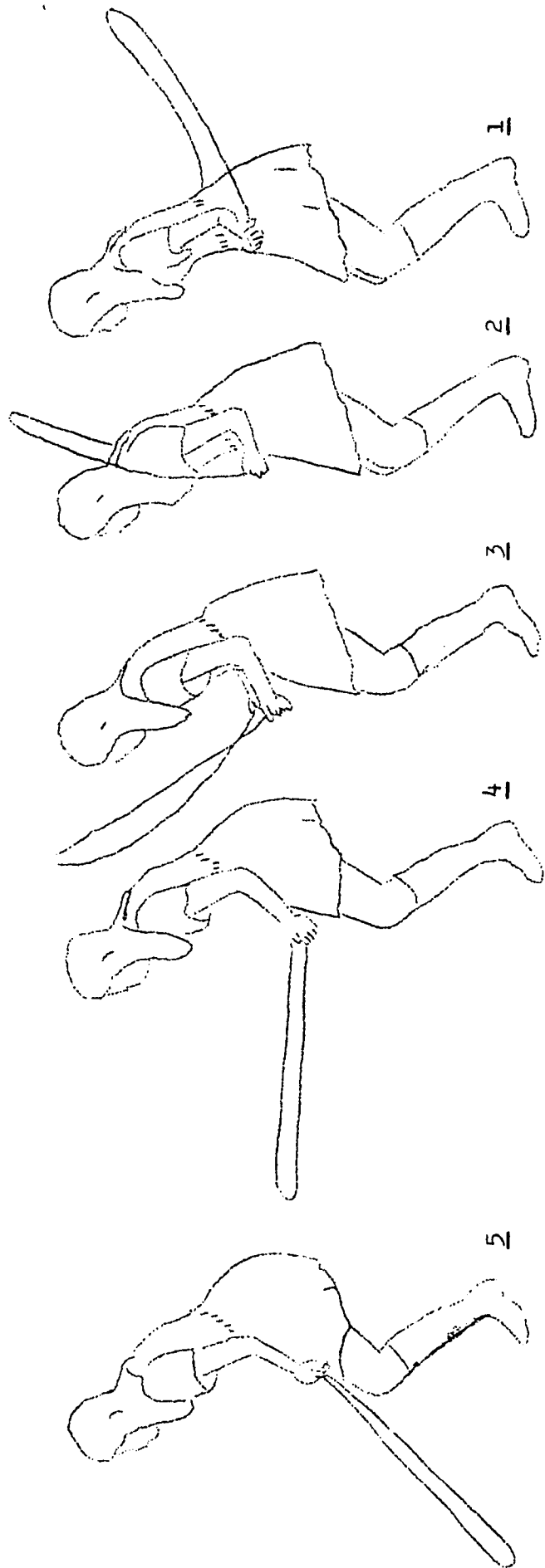


FIGURE I. Rope jumping form of an 11-year-old girl who was filmed while jumping at the rate of approximately five turns per second. The rather crude line drawings show the economy of movement that characterizes mature form. The legs are lifted to allow space for the rope to pass under the body, the hands move minimally and turn the rope in a circular path.

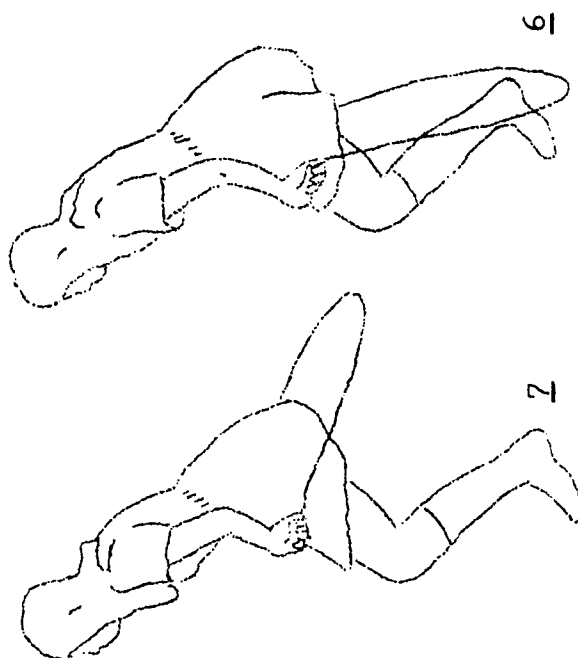


FIGURE II. (next page) Front view of the same girl. Minimal arm and leg action again is evident, as is the leg lifting motion rather than a "jumping" action for rope clearance.

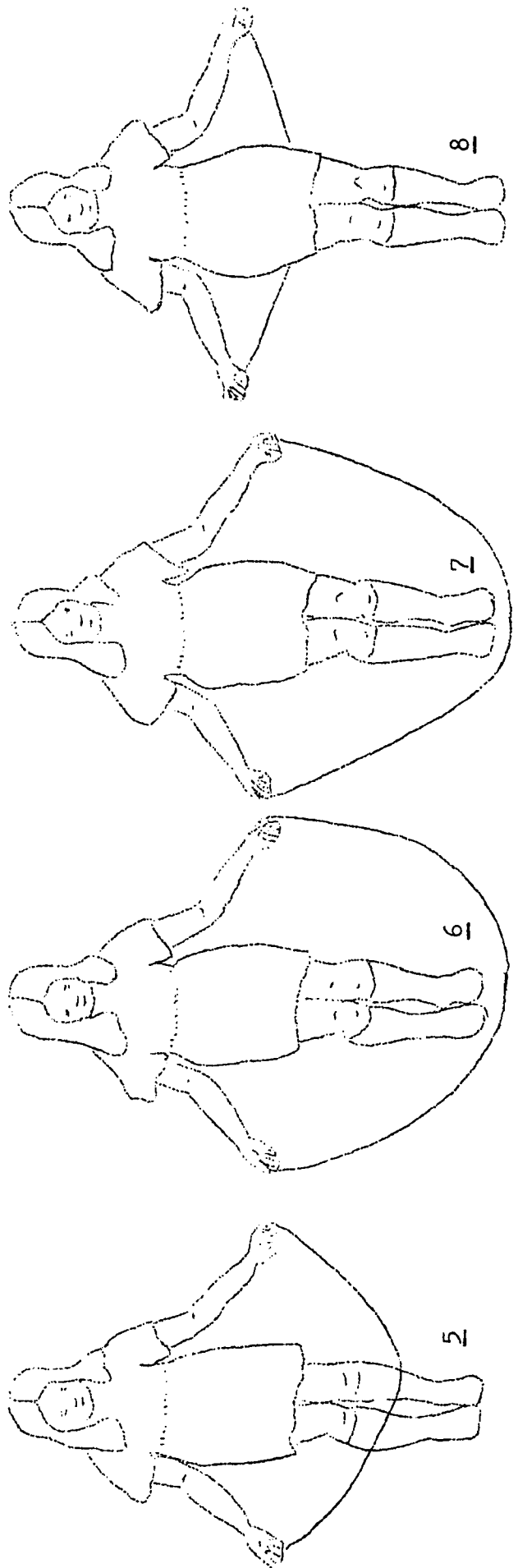


FIGURE II

Sub-minimal performance. There is a minimal form that must be met for a movement pattern to qualify as a particular skill. For the purpose of this study, minimal form in rope-jumping was described as being at least two consecutive successful rope jumps executed while the rope continued to be turned. Only 3 of the 17 nursery school children met the standard while 82 of the 103 kindergarten children satisfied the criterion. Observations were made on some of the common aspects of the sub-minimal performances.

The single-minded goal of the beginner seems to be to turn the rope and jump over it one time. He seems not to think in terms of continuity initially and usually exaggerates his effort to achieve the one jump goal. A unitary pattern in which the jump and the turn start at the same time is common. Exaggerated upward leg action accompanied by deep forward trunk bend is also quite typical and it works against continuity. Another major problem is the awkward position of the arms when the hands move backward beyond the body plane as the rope is being turned. Hyperextension of the shoulder tends to block the turning motion. Consequently part of the momentum of the rope is lost and when the rope is moved again it goes forward into the jumper rather than upward and over his head. After the child has sorted out and solved these critical problems of timing and arm action, he is able to progress to the point of satisfying the criterion for minimal form.

Developmental form.

The major difference in rope jumping style used by children who have achieved minimal form is in the type of jumping action used. Among the possible techniques for jumping are a one- or a two-footed jump with or without an intervening rhythmical hop, a step-push type of jump, and a skipping or a running type of jump. The child most likely

adopts the first model to which he has been exposed when he makes his initial attempt at rope jumping. Use of the intermediate hop in some form seems to accompany achievement of minimal form and thereafter other styles are picked up handily. However, there is a significant narrowing of the jumping variations used as speed is added to the performance.

1. Developmental changes in the Arm-Hand turning pattern. In the earliest successful pattern, the hands start at shoulder height, go forward and downward as the arms extend at the elbows. The hands remain about shoulder width apart until they start backward, at which point they begin to move sideward with the elbows bending to allow forearm rotation and wrist circumduction. The thumbs extend outward as the hands pass the backward plane of the body and then move upward and inward to the high starting position. This pattern of movement produces the narrow elongated loop at the front of the turn and a wide, foreshortened loop at the back of the turn.

Progressively the arm-hand movement pattern in the rope turn undergoes change. Some of the notable changes are:

- a. The hands move through less total range of motion each turn.
- b. The loop of the turn becomes less oval and more circular.
- c. The center of the turning motion for the hands moves more forward.
- d. There is an increase in the looseness of wrist and forearm movement.
- e. The hands remain away from the sides during more of the turn.
- f. The angle at the elbow becomes more constant throughout the turn.

These developmental changes seem to be quite interdependent and they occur gradually and coincidentally. However, there is a definite

acceleration in the rate of change in the pattern producing the rope turn after the intermediate hop has been eliminated from the jump. Progress toward mature form is much more rapid following that change in form.

2. Developmental changes in jumping movements. In their early attempts at rope jumping, children often jump forward over the rope as they would in doing a standing long jump. The folly of this practice becomes apparent when it consistently interferes with continuity and the child gradually changes to the more effective approach of jumping upward while passing the rope under his feet. The step-push jump and the two-footed jump are most commonly used by the beginner to clear the rope. There usually is an intermediate hop in both styles and they are similar in at least one other important respect. Both involve extensive bending at the knee after leaving the ground in order to get the feet well off the ground at the height of the jump. The effort seems directed at creating an abundance of space for the rope to pass through and it helps provide a wide margin for error in the timing of the jump with the turn of the rope. By contrast, the intermediate hops are simply miniature jumps with the feet barely leaving the ground. These hops are mostly for rhythm and allow slow rope turning which is helpful to the minimal-form jumper.

Space and time do not allow an elaboration of the unique changes connected with improvement in each of the jumping forms just mentioned. However, there seem to be a few general trends in the jump phase of the pattern which apply to both common styles:

- a. There is increasingly less total height in the main jump for each rope turn.
- b. There is progressively less flexion at the knee joint during the main jump.

- c. The legs are increasingly closer together during the jump.
- d. The intermediate hop during each turn is finally eliminated.
- e. There is a slight temporary increase in the height of the jump when the intermediate hop is eliminated.

The change from a jump with an intermediate hop to the single jump is a critical developmental change because it removes the major barrier to an increase in speed which is required in mature form. The other changes are progressive and seem to occur more or less coincidentally.

3. Developmental changes in jump-turn coordination. Coordination of the turn and the jump is directed toward the goal of having the height of the jump reached at the instant the rope passes under the body. The urgency of this timing increases as the speed of the rope increases and the height of the jump decreases. In the developmental stages when the rope is turned slowly to accommodate the rhythmical hop, there is a reasonable margin for error in the timing. The jump starts when the rope is somewhere in the upper forward quadrant of the swing. The step in the step-push style of jump starts during the time the rope is in the same part of the turn. If the jumper is not using a hop, the rope turn is faster and he begins his jump slightly earlier. The jump is timed to begin when the rope is more toward the vertical.

The speed of the rope is not uniform throughout the turn when slow jumping is being done. It obviously is greatest in the lower front quadrant of the turn when the rope is pulled backward and under the feet. As the speed of jumping increases the rope movement becomes conspicuously more uniform. A precise study of this aspect of form promises to be one of many intriguing future projects connected with rope jumping.

There is a crucial point in the lower back arc of the rope turn

when it seems especially difficult for the beginner to prevent the loss of the momentum of the rope. This was mentioned before in connection with the awkwardness of the arm-hand movement at that point. A slight hitch in the turning motion in that part of the swing can quickly upset the timing and interfere with the continuity and rhythm of the rope jumping skill. As the speed of jumping increases, the demand for precise timing of the movements likewise increases. With less time to complete the total pattern, there is diminished margin for error in the coordination of the turning and jumping movements. As the jumper is able to increase his speed, he automatically demonstrates an improvement in the timing of the parts of his movement pattern.

Rope jumping is distinguished by being one of the first relatively complicated arm-leg coordination skills learned by a majority of the children in this country. This preliminary report suggests that it is a skill worthy of more detailed study both in terms of the concept of mature form and with respect to the analysis of developmental changes.